PORTABLE URANIUM SURVEY TOOL USING LASER-INDUCED FLUORESCENCE IMAGING

TECHNOLOGY DESCRIPTION

Laser-induced fluorescence uses light to stimulate optical emission in materials. Laser-induced fluorescence imaging (LIFI) uses this principle to generate images in real time. The technique is a surface survey capability, as the light directly excites the uranium +6 valence oxide [U (VI)]. In the case of uranium oxide detection, the green emission is phosphorescent, allowing for discrimination from background fluorescence by time gating. The surface contamination data are displayed as a real-time, false color image that is stored as a digital file on a removable PC card. The portable system will provide real-time analysis permitting timely decisions to be made at the survey site.

TECHNOLOGY NEED

Several areas and facilities on U.S. Department of Energy (DOE) sites have the need for rapid, real-time survey technologies that can determine the presence of surface contamination and distinguish selected elements, such as uranium, from significant background radiation levels. For example, rapid, real-time survey sensors are needed to efficiently survey areas and facilities like the UF6 cylinder storage yards and walls, ceilings, floors, pipes and equipment in the K-25 buildings at Oak Ridge National Laboratory (ORNL) that are scheduled for decommissioning and demolition. Several DOE sites have scrap metal parts that they would like to screen for release. In the case of scrap metal, uranium may be present in a thin film at low activity levels (less than one-thousand disintegrations per minute), making it impractical to survey by conventional techniques–especially when large areas need to be surveyed. The portable LIFI sensor system can quickly identify moderate levels of uranium oxides on surfaces even when there is a significant radiation background that tends to mask its presence using conventional detection techniques. The system can be run by on-site or subcontractor health physics personnel. The baseline techniques are the use of Geiger Mueller "Pan Cake Friskers" and chemical swipes. Field radiation detection instrumentation is commercially available, but these technologies are not as cost effective for most large area applications as LIFI. Overlaying the LIFI contamination data on a visual image in real time is an immense help in defining where the uranium oxides actually are located.

A related development is the engineering of tailored chemical materials that cause non-fluorescent materials to become fluorescent and, therefore, made detectable by LIFI. Chelates and sequestering agents are used to cause a fluorescent indication of contamination on surfaces. More importantly, these agents can be used to detect small leaks in waste transfer pipelines and similar situations where high background radiation levels mask the presence of uranium. Several of these chelates, or “enabling technologies,” were developed in this work. An additional purpose is to identify the cesium ion in strippable coating applications.

The following are some of the needs identified by Site Technology Coordination Group (STCG) that are addressed by the portable LIFI uranium detector:

- ORDD-12 - Improved Characterization of Buildings and Facilities.
- OH-M901 - Improved Facility Survey Techniques.
- ID-7.2.06 - Remote Characterization.
- AL-07-06-01-DD - Decontamination and Decommissioning (D&D) Technology Development.
- RL-DD035 - Visual/Spatial Imaging of the 221-U Facility and Equipment for Canyon Disposition Initiative (CDI).
- NV-10-9902-09S - Improved Detection and Characterization of Radioactive Contamination on Large Concrete and Metal Surfaces.

TECHNOLOGY BENEFITS

- *Selectivity:* Fluorescence techniques have the ability to detect and recognize spectral signatures that are not observable by conventional or baseline methods. As a screening tool, fluorescence allows for the determination of surface exposure, improving worker safety, and allowing a rapid assessment of hot spots.
- *Screening Tool:* The system can image at a distance, allowing access to out of reach areas.
- *Spatial Resolution:* The high spatial resolution of intensified charged coupled device (CCD) cameras and the time-resolved phosphorescence emission characteristic of the uranyl ion allow a picture to be created that shows the extent of surface uranium contamination. This visual image allows mitigation efforts to be focused on specific areas and that speeds the survey and lowers overall costs. At distances of 4 feet, the spatial resolution observed is better than 1 centimeter.
- *Real Time:* The real-time image processing of the data into a false color composite on a gray scale background allows the operator to quickly distinguish the uranium signature. Since the data are recorded as digital Tagged Image File Format (TIFF) files, it can be reviewed for planning and review of deactivation and decontamination activities.
- *Portable:* The present LIFI configuration is probably the only system that can record LIFI imagery from a single, portable system. No commercial equivalent to the LIFI technology exists.
- *Cost-Effective:* A cost-benefit analysis has shown that the system becomes a cheaper alternative to swipes and Geiger-Mueller Tube (GMT) meters at a relatively small area (Cost curves cross at 30,000 square feet).
- *No Secondary Waste:* As an optical technique, the LIFI system generates no waste.
- *Operates in High Radiation Background:* The system is not affected by underlying radiation sources such as pipes. This allows for the determination of surface contamination on a high radiation vessel.

TECHNOLOGY CAPABILITIES/LIMITATIONS

In areas where there is a potential health risk, such as often is found during some deactivation and decommissioning operations, the health physicist monitoring with LIFI can stand many meters away from data acquisition. This has been demonstrated at both the Fernald Site in Ohio and at the K-25 Site in Oak Ridge, Tennessee. The standoff from sources of radiation exposure also allows quick surveys of overhead areas not accessible without ladders. More traditional radiation tools such as gamma and beta meters can then be used, if necessary, at identified “hot spots” to quantify the levels present.

In areas of high background radiation, the LIFI technique detects the exterior contamination with no signal interference from the radioactive material in the container. This detection was demonstrated at the UF_6 cylinder storage yard (E yard) at the K-25 Oak Ridge Gaseous Diffusion Plant. By expanding the monitoring and characterization to include the enabling technologies (chelating agents that activate fluorescence), seals and connection flanges can be monitored rapidly for leaks. LIFI detects the leaks as chemical signatures that are unaffected by the high radiation backgrounds.

LIFI, however, is limited to detecting uranyl oxides, the dominant contamination at processing sites. The uranium oxide [U(VI)] is fluorescent while the other oxidation states are only weakly observed or dark. Fortunately, the U(VI) dominates many stages of the production process. The other oxides may be detectable through the use of the tailored chemical material enabling technologies. Because DOE free-release criteria includes all radioactive materials, the system is not appropriate for free release, but can be used in a toolbox of characterization techniques.

COLLABORATION/TECHNOLOGY TRANSFER

Technology transfer is currently envisioned to include continued participation with the DOE Environmental Management (EM) partners at Oak Ridge (K-25) resulting in the eventual replication of the deactivation and decommissioning tool. If commercialization is deemed appropriate and economically rewarding, a commercial partner will produce the units. If several units are required for immediate deployment, several more would be produced in-house for DOE use. In addition to uranium cleanup, other applications will benefit from the real-time fluorescence survey capability. New users, both inside and outside the DOE, have been identified DOE (petroleum leaks), law enforcement (forensic applications), and vegetation monitoring (agriculture). Systems have been provided to non-DOE EM customers.

These are the components of a portable Laser-Induced Fluorescence Imaging (LIFI) and filtering technique for real-time uranium detection.

ACCOMPLISHMENTS AND ONGOING WORK

The LIFI technology has been demonstrated at a variety of DOE sites. The original system used to make the first LIFI measurements weighed 1,500 pounds. The intermediate system weighs 150 pounds including the batteries. In its final configuration, the survey tool weighs about 39 pounds and can be carried like a backpack. It has been designed to be easily replicated from original equipment manufacturer (OEM) components. Laser and camera components can be detached readily for servicing by the original manufacturers. The system is easy to use and has a simple user interface that stores tagged image file format (TIFF) digital imagery that can be imported in word processing packages.

TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: NV05C253 - Portable Laser-Induced Fluorescence Imaging System

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